

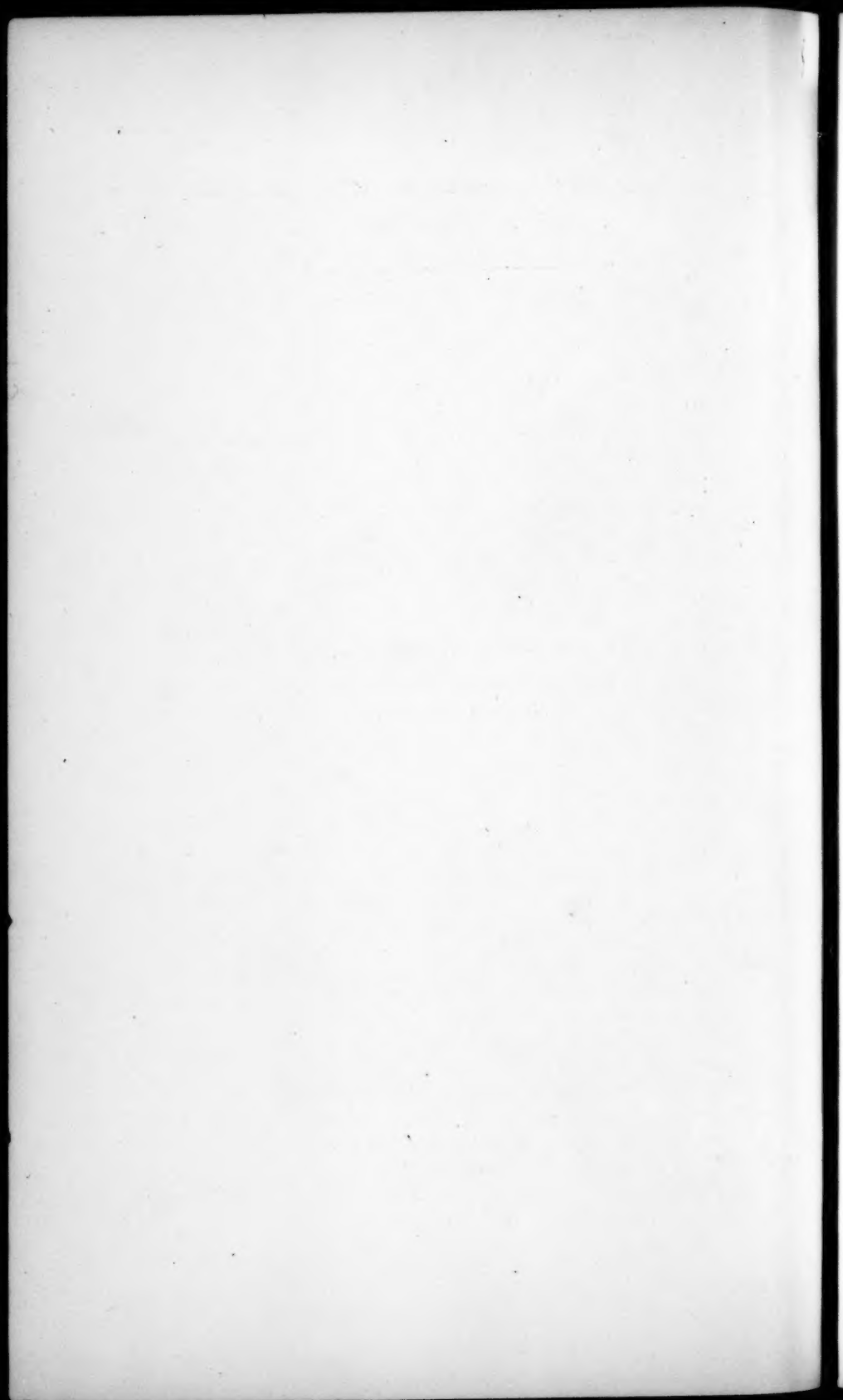
Proceedings of the American Academy of Arts and Sciences.

VOL. XXXVI. No. 21. — MARCH, 1901.

---

*DESIGN AS A SCIENCE.*

BY DENMAN W. ROSS, PH.D.,  
LECTURER ON THE THEORY OF DESIGN IN  
— HARVARD UNIVERSITY.



## DESIGN AS A SCIENCE.

BY DENMAN W. ROSS, PH. D.

Presented January 9, 1901. Received January 12, 1901.

ART may be defined as the expression of Life, or, more specifically, as excellence in the matter of expression; and excellence, in this case, may be defined as consistency, a consistency in forms of expression. Consistency has many manifestations, but they fall under three principal heads: Balance, which is a consistency of oppositions (antitheses); Rhythm, which is a consistency of association (joint action or movement); and Harmony, which is a consistency of character (likeness). If art is consistency in forms of expression, Balance, Rhythm, and Harmony are its principles. They are also the principles of Beauty. We have no other definite conception of beauty. It is a perfect relationship or connection of parts in one organic whole. We find this unity in nature, when we seek it, and we find it in the art of man, *homo additus naturæ*. Wherever and whenever we find it, we have the perception of beauty.

The idea which the Greek philosophers had of art was as nearly as possible the one which I have given as the major premise of this argument, and it is in the art of the Greeks that I have found its most perfect illustration. See Plato, in the *Gorgias* (§ 504): "The artist brings all things into order, making one part to harmonize and accord with another, until he has constructed a regular and systematic whole; this," Socrates says, "is true of all artists." Aristotle expresses the same idea when, in his *Poetics*, he speaks of poetic imitation having "as its subject, a single action, whole and complete, with a beginning, a middle, and an end. It will thus," he says, "resemble a living organism and produce its proper pleasure." See *Poetics*, xxiii. 1.

While consistency in forms of expression may be regarded as a definition of art, it is not, of course, a definition of what is significant or important in art. We can take a few lines and put them together so that they shall be absolutely consistent, expressing one idea, unmistakably. The result is a work of art, but the work is unimportant. It is an easy thing to do. The work of art is important in proportion to the number

and variety of elements which are reconciled and united in its idea. Consider, for example, Raphael's *Dispute of the Sacrament*. Think of the number and variety of the elements united in that great composition. Such a design is an achievement representing intellectual power of the very highest order. So we discover, as the principal factor in art, the mind of the artist, and the measure of this is observed in his ability to see in many things one idea, and to express in one idea many things. Beyond this power of the mind to grasp and express many things in single ideas, a power which we can analyze, understand, and appreciate, lies something which defies analysis, something which we may appreciate, but which we cannot understand. This is the strictly personal element which goes into the work of a man, which stamps it as his, which distinguishes it from the work of other men. This personal element, when it is important, we call genius. The genius of the artist in his art is constantly mistaken for the art itself. It seems to me that the genius of the artist is something which lies beyond his art. His art is simply the technique in which, and through which, his genius finds expression. In speaking of art, therefore, I am speaking of the technique of expression and nothing more than that. That is a matter of precise definition and analysis. There is a passage of Plato in the *Philebus* (§ 55), where Socrates says, "If arithmetic, mensuration, and weighing be taken from any art, that which remains will not be much." In talking about art and its principles, I mean art in this definite sense. There is a passage in the eleventh canto of the *Inferno* of Dante which is significant in this connection: "If you read your physics attentively [Dante refers here to the physics of Aristotle], you will discover, after not many pages, how your art follows that [physical science] just as far as it can, as the disciple follows the master."

There are many arts, the different modes and forms of expression: gymnastics (including dancing); music, speech (including poetry); construction (including architecture); modelling (including sculpture); and painting (including design). The particular art to which your attention is called in this paper is the art of painting, in its highest form, Design. Painting may be defined as expression by spots of paint, paint being in this case any coloring material, no matter what it is, that may be used. Design is painting with particular reference to the principles of art. We have painting as Design and painting as Representation, which is the definition of visual impressions, a description of things seen, remembered, or known, and we have Design in Representation. Design in which there is no representation, or in which the elements of representation are not

considered as such, may be called Pure Design. This may be defined as the arrangement or composition of spots of paint for the sake of balance, rhythm, and harmony; for the sake of consistency, unity, beauty. Pure Design appeals to the eye just as music appeals to the ear. The term of expression in music is the sound; the term of expression in design is the spot of paint.

The spot of paint is three things: it is a tone, a measure, and a shape. By *tone* I mean the pigment material used in drawing the measure of the spot and its shape. By *measure* I mean the area covered by the spot, its size. By *shape* I mean its outline, or contour. Put a spot of paint upon a piece of paper, then change (1) its tone alone; (2) its measure alone; (3) its shape alone; (4) its tone and measure, leaving its shape unchanged; (5) its measure and shape, leaving its tone unchanged; (6) its tone and shape, leaving its measure unchanged; (7) change its tone, its measure, and its shape, producing an altogether different spot.

Taking the spot of paint as the subject of my investigation, I will consider, first, the element of tone, then the element of measure, and, lastly, the element of shape. In order to study the element of tone we must eliminate all differences of measure and of shape, which might be confusing. Producing as many different tones as we can, in circles of half an inch diameter, we find that we can produce a very great number and a very great variety. Looking over the tones we have produced, we observe that every tone is relatively light or dark. It has what is called value. It is a measure of light in the white-to-black scale. Observe, also, that every tone has a color. It is red, or green, or violet, or some other color, and the color which it has is relatively intense or neutral, or it may be quite neutral. We shall find it convenient to regard the neutral as a color. It is the color of white, or gray, or black. Tone means, according to these observations, two things, — value and color.

We will consider, first, the element of value, afterwards, the element of color. In considering values alone we must eliminate all differences of color which might be confusing. Take the neutral pigments, white and black, and see how many neutral values you can produce in circles of half an inch radius. You can produce seventeen certainly, and perhaps a few more. You will observe that in producing as many as seventeen neutral values you are nearing the limit of visual discrimination, the limit of distinct definition, or expression. Observe that every value which you have produced is a force drawing attention to itself. Observe that different values exert different degrees of attractive force, that this force is determined in each case (other things, measure, shape, and color, being equal)

by its contrast with the ground-tone upon which it has been drawn. If the ground-tone is white paper, the value having the greatest attractive force is black; if the ground-tone is a half-tone between white and black, the forces of white and of black are equal. What is the result of all these forces of attraction, as they act upon the eye? The eye is held at rest at their centre of equilibrium. Where is that centre? In order to answer this question, we must bring the values into a scale-relationship upon a common ground-tone, otherwise we have no means of measuring their respective contrasts, or the forces of attraction which depend upon their contrasts. Make a scale of seventeen values, exclusive of white and black, in seventeen circles of half an inch radius, in a straight line, half an inch apart, and upon a ground-tone of the middle value. Be sure that the values are at equal intervals of equal contrasts. In order to get them into the perfect scale-relation which this implies, establish the extremes first, then the mean between the extremes, then intermediates, until the scale is complete. The interval or contrast between value and value may be great or small; the scale may be central in pitch, high in pitch, or low. It is central in pitch when its middle value is at the half-point between white and black. Considering the scale of values which you have produced, you observe what you have observed before, that each value is a force of attraction, that this force, other things being equal, depends upon the contrast with the ground-tone. The only value which has no force of attraction is the central one of the scale, the value which coincides with the ground-tone and cannot be distinguished from it. Looking at the scale again, pick out the values which have the same force of attraction. They will be those at equal distances from the half-tone, which is the ground-tone, making equal contrasts with it. In order to distinguish the different values of the scale, we will call the middle value zero (0). The values above the middle value we will call 1, 2, 3, etc., *above*. The values below the middle we will call 1, 2, 3, etc., *below*. The values above can be written thus: 1, 2, 3, etc.; the values below thus: 1, 2, 3, etc. The values having the same force of attraction are, then, those having the same numbers:  $\frac{1}{1}, \frac{2}{2}, \frac{3}{3}$  etc. The numbers are the measures of the contrasts, and of the forces of attraction depending upon the contrasts. If now we scatter our seventeen values over the ground-tone of the middle value we shall be able to discover the centre of equilibrium of their forces, that is to say, the point where the eye is held by them. We have simply to remember the familiar principle of balance; that equal attractions balance at equal distances on a line connecting their centres;

while unequal attractions balance in the same way, but at distances which are inversely proportional to them, as attractions. Measures, shapes, and colors being equal, values alone differing, values 4 and 1 balance on value 0, at distances 1 and 4 respectively. If the ground-tone were 2 instead of 0, 4 and 1 would balance on 2, at distances 1 and 2 respectively. In this explanation of the balance of values we find the principle upon which the designer proceeds when he wishes to create such a balance. He may prefer to depend upon his visual feeling, but his feeling must be guided by the law of balance whether he thinks of the law or not.

The scale of values is not merely a scale of visual attractions to be balanced, it is also a rhythmic movement of values. The scale-relationship is not, properly speaking, a relationship of opposition or antithesis; it is one of association or joint action. The values of the scale combine to lead the eye in a movement from light to dark, or from dark to light, and this movement is easy in proportion to the perfection of the scale. If the scale is imperfect, if the intervals are not equal intervals of equal contrasts, we have the same discomfort that we have in walking on the irregularly placed sleepers of a railway track. We all know how tiresome it is to do that. Not only is the eye led in the scale of values from dark to light and from light to dark, but if the values be squeezed together the eye is led quickly or abruptly; if they are pulled apart the movement is comparatively slow or gradual. By changing the direction or the shape of the scale of values the eye may be led in different directions, and its movement may take a variety of shapes. A few simple diagrams would show the rhythmic character of the scale of values in these several aspects. Values are in harmony when they are in the same scale, and when the relations of the scale can be felt, visually. The least contrast of the scale is a factor of the greatest, and when this relation is distinctly felt we have a perception of harmony. The most perfect harmony is that of corresponding values.

Tone, as we have seen, means two things: value and color. We have been considering the element of value. We will now consider the other element, color. In order to do that satisfactorily we must eliminate all differences of value. Producing as many differences of color as we can, all in the same value (the half-tone between white and black), and all in the same measure and shape (the circle of half an inch radius), we shall find that we can produce perhaps twelve differences of color, and in each color a certain number, perhaps eight differences of intensity. In order to study color without being confused with the differences of intensity, let us put all the colors not only in the same value, but in the same degree

of intensity, the greatest intensity possible to the pigments on our palette. This being done, we shall observe, at once, that the colors have a natural order or connection with one another. Red passes into green through yellow; yellow passes into blue through green; and blue passes into red through violet. There is, in other words, a natural relationship for all the colors we can produce in the same value and intensity. There is a natural scale of colors, as there was a natural scale of values. This scale of colors is, of course, the scale of the spectrum. The spectrum which I have followed in this investigation, is the normal spectrum, the spectrum of the grating, not the spectrum of the prism. The difference is explained by Rood, by Lommel, and by other writers. Reading the spectrum from the red end towards the violet end, the colors follow one another, approximately at equal intervals of equal contrasts, as follows: red, suggesting Chinese vermilion; yellow, suggesting aureolin; green, suggesting emerald green; blue, suggesting cobalt with a little emerald green in it; violet, suggesting ultramarine with a little rose madder in it. Beyond the violet end of the spectrum we may observe the color which we call purple. It suggests rose madder with a little ultramarine in it. This color does not belong in the spectrum series. It is due to the overlapping of the red and violet ends of the spectrum. It is, however, a color which we must use, and if the primary or important colors of the spectrum are red, green, and violet, purple exists for us as an intermediate between red and violet, just as yellow is intermediate between red and green, and blue between green and violet. Between the six colors, red, yellow, green, blue, violet, and purple, come intermediates and the intermediates of intermediates up to the limit of visual discrimination. Setting the normal spectrum upon the circumference of a circle, with purple as a connecting link between the ends, the interval between any two colors can be described as an interval of so many degrees. We have an interval of  $60^\circ$ , the interval separating red from yellow, yellow from green, green from blue, blue from violet, violet from purple, adjacents in the scale of six colors. We have the interval of  $120^\circ$  between the adjacents of a scale of three colors, — red, green, and violet, for example; and we have the interval of  $180^\circ$  between the adjacents in the scale of two colors, — red and blue, for example. This is the greatest possible interval. It is the interval between colors opposite one another in the circle, the colors which we call complementaries. In order to study the various intervals of the scale of colors with certain conclusions, we must eliminate all differences of value and all differences of intensity. We can then see

which intervals give the greatest satisfaction to the sense of vision. The attempt to reach conclusions on the question of color-contrast, by comparing colors in different values and of different intensities, is perfectly futile.

The greatest possible interval in the color scale is, as I have said, the interval of  $180^\circ$ , the interval between opposite colors of the circle. These colors are known as complementaries. In the scale of six colors there are three pairs of complementaries: red and blue, purple and green, yellow and violet. For the sake of brevity we will indicate the colors by their initial letters: R for red; Y for yellow; G for green; V for violet; B for blue; P for purple; N for neutral. For the scale of neutral values we have already a terminology. Complementary colors, when tones of the same value and intensity are mixed together, neutralize one another, approximately. The relation of the complementary colors may, therefore, be stated in this form:—

Y — N — V
R — N — B
P — N — G

Observe that the complementaries balance, one against the other, on the intermediate neutral, when of the same value and intensity. The degree of intensity may be represented by the distance or space between the sign of the color and the sign of the neutral which separates it from its complementary. The greater this distance the greater the intensity. In the statement which follows, yellow and violet and purple and green are all equally intense, but the red and the blue are twice as intense:—

Y — N — V
R — — N — — B
P — N — G

The complementaries balance on the intermediate neutral, other things being equal, at equal distances from one another on the straight line connecting their centres. But in the arrangement

R — N — — B
-------------

the neutral being the ground-tone, the red being only half as intense as the blue, it will have to be moved to twice the distance, unless its

measure or quantity is doubled. I shall, presently, speak of measure as an element of balance.

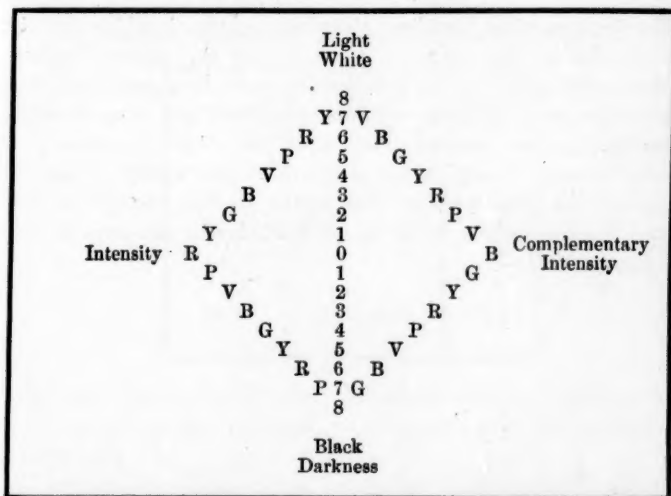
When it comes to the consideration of color intervals we have to think not only of the interval between one color and another in the spectrum scale, but, also, of the interval between each color and the neutral in which it disappears and is lost to vision. Take red, for example, in its greatest possible intensity, an intensity limited by the pigment material which we possess. This red is contrasted not only with its neighbors in the scale of colors, purple on the one hand and yellow on the other, but it is contrasted with itself in various degrees of neutralization. Establishing the greatest possible intensity of red on the one hand and a perfect neutrality on the other, both in the same value, and using for measure and for shape the circle of half an inch radius, make a scale of nine tones of red, the extremes of intensity and neutrality being included in the scale. What has been said of the other scales may be said of this one; a repetition is unnecessary.

We have considered the scale of values and the scale of colors separately. Now let us put the two scales together. The values being neutrals in every case, we can set complementary scales of colors on the right and left of the scale of values. That will give us two scales of colors, and between them the scale of values, as follows: —

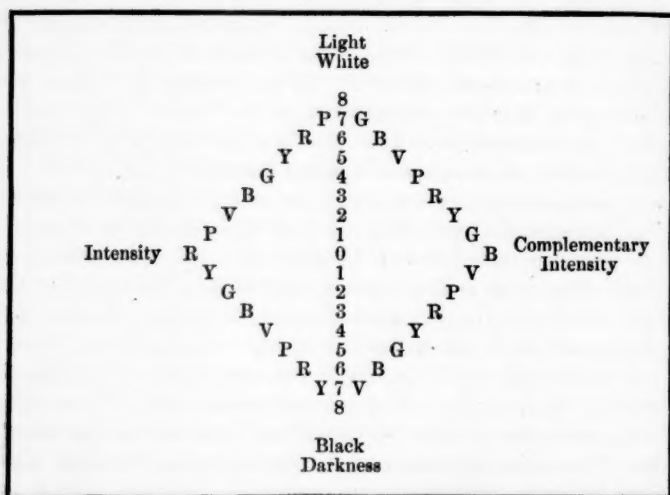
Light White		
G	8	P
Y	7	V
R	6	B
P	5	G
V	4	Y
B	3	R
G	2	P
Y	1	V
R	0	B
P	1	G
V	2	Y
B	3	R
G	4	P
Y	5	V
R	6	B
P	7	G
V	8	Y
Black Darkness		

Following this diagram, put in the place of the value numbers values of neutral color, moving from the central neutral up towards light (white)

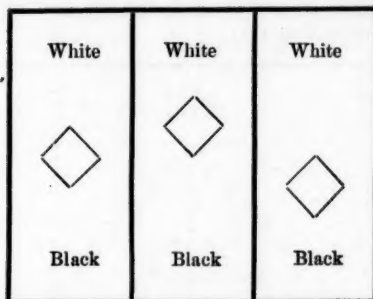
and down towards darkness (black). Then, on a ground-tone of the central neutral, alongside of the values and in the values, set the colors in spots of paint, all in the same intensity: if you can. You will immediately discover that you cannot do this. The colors in the light values are inevitably neutralized by white, and colors in the dark values are inevitably neutralized by black or some equivalent dark neutral. It is only towards the centre of the scale of values that you can get to any considerable intensity of color. If you consider the matter you will understand that this neutralization of the colors in light and in darkness is as it should be. It is exactly what happens to the colors in nature as they occur between light and darkness. Color is observed in its greatest intensity at the half-point between the light, whatever it is, and the darkness, whatever that is. It is evident that the form in which I have described the relation of the color and value scales needs to be modified. The colors as they approach the half-point between light and darkness must become more and more intense, the greatest possible intensity being reached at the half-point, exactly. We have seen how the measure of intensity can be indicated, diagrammatically, by increasing or diminishing the space between the complementary colors in any value and the intermediate neutral; so all we have to do in order to describe the law of increasing and decreasing intensities is to pull the color scales apart at the half-point between the extremes of light and of darkness. This has been done in the diagram which follows: —



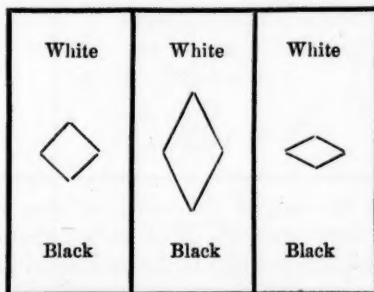
It will be found that this system works just as well if we turn it upside down. In doing this the relation of the color scales to the value scale is reversed, as in the following diagram:—



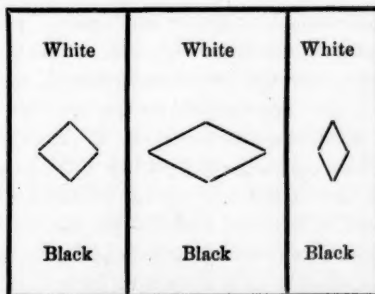
The diagrams which have been given show systems in which the colors red and blue are the dominant colors, having the greatest intensity. Predominance might be given to yellow and violet, or to purple and green, or we might bring the point of intensity between two pairs of complementaries. In that case we should have four colors as dominants, all equally intense. Every change of the dominants means, of course, a change of the whole system. The system may be changed in other ways. We can raise or lower its pitch within the extremes of white and black, thus:—



We can extend or contract the scale of values, thus : —



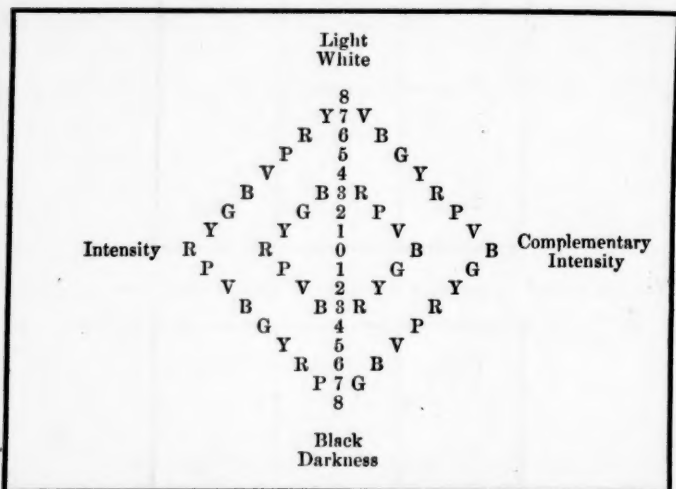
We can increase or diminish the degree of intensity, thus : —



By these various modifications an infinite number of specific forms of the system can be developed, all consistent with the system in its abstract idea.

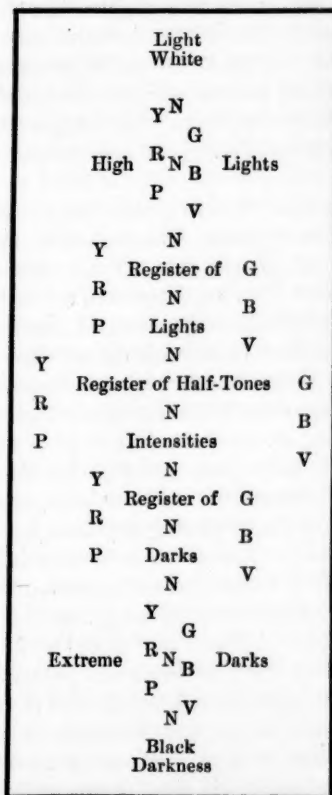
If necessary, a system of half lights, half darks, and half intensities

of color can be used in connection with the one described, in the manner shown in the following diagram: —



As we increase the number and variety of tones to be kept all at equal intervals of equal contrasts, all in perfect rhythm and balance, the problem of consistency, which is the problem of art, becomes more and more difficult.

There is a possible objection to the system of color-values or tones which I have described. In the spectrum the colors are all equally intense. They differ only in value or luminosity. In the system just described this equality of intensity is ignored, and as to the luminosities, if they are observed on the hot side of the spectrum, they are ignored on the cold side, and if they are observed on the cold side they are ignored on the hot side. A different arrangement of values and colors is possible. If we distribute our range of light into five registers, — a register of half-tones, a register of lights, a register of darks, a register of high lights, and a register of extreme darks, — we can consider each one of these five registers as a potential spectrum, and we can arrange the colors in each register according to their several values or luminosities and have them all equally intense. The increase or diminution of intensities is not, then, from color to color but from register to register. In the scale of five registers, the middle one will be the register of greatest intensities. The registers above it and below it will be registers of less and of least intensity. This system is described in the following diagram: —



This system would seem to be a particularly natural and proper arrangement of the values and the colors, for, if you throw the spectrum on white paper in sunlight the colors are seen all pale in the white light, equally intense so far as you can see them, but with the differences of value or luminosity which are indicated in the diagram. If you throw the spectrum on white paper in shadow (half light), you see the colors in equal intensity and in the greatest intensity, with the same differences of luminosity. If you throw the spectrum on black paper in shadow, you will observe the same equal intensity of colors, so far as you can see them, and the same differences of luminosity, but the whole spectrum is disappearing in neutral darkness. This system of color-values or tones

in which we have a spectrum to a register, in which the colors in each register are all equally intense, but in values representing their several natural luminosities, cannot, of course, be turned upside down, because that would reverse the luminosities; but the system admits of the other changes which I have described, — the changes of pitch, the extension or contraction of the value scale, and the extension or contraction of the intensities.

When it seems desirable, the middle register of greatest intensities may be left out of the system. The register of lights and the register of darks can then be brought close together, just above and just below the central neutral. Then the lights and the darks are all equally intense, and the first diminution of intensity is found in the register of high lights and in the register of extreme darks. This arrangement may be used both in Pure Design and in Representation. It is a system which ought to give great satisfaction to the colorist because of the number and variety of the colors, all equally intense, which it allows him to use.

If you take your palette and, following any of the diagrams which I have given, work out an illustration of the system, taking the central neutral as ground-tone, and putting the tones in circles of half an inch radius, you will observe that you have in the relationship of the tones a relation of balance, of rhythm, and of harmony. The system, whichever system it is and whatever form of the system is followed, is an illustration of Pure Design. Again, I am tempted to quote a passage of Plato in his Symposium (§ 187), in which the physician Eryximachus says that "harmony is composed of differing notes of higher or lower pitch which disagreed once but are now reconciled by art." In these various systems of color-values or tones, we have a reconciliation of many differing elements harmonized by the art of design. Observe how the rhythms of the different scales are so disposed that they balance in a perfect equilibrium, and how by the principle of equal intervals of equal contrasts the many elements of each system are all perfectly related.

Now we must take up and consider the second element of the spot of paint, — measure. In order to do this without confusion, take one tone, black on white paper, and one shape, the square. Thus eliminating all differences of tone and of shape, you can vary the measure and study it in all possible variations. Take some white paper and draw on it five black squares of different sizes. Observe that you have harmony of tones because the squares are all black, and you have harmony of shapes because the shapes are all square, but you have no harmony of measure. There is no connection between your measures, unless you have made

one, intentionally. It would not happen by accident. Now draw five squares in a scale, so that they shall be as 1 to 2, to 4, to 8, to 16, to 32, in the proportions of their measures. This is easily done by drawing the second on the diagonal of the first, the third on the diagonal of the second, and so on. Observe the difference between the five related and the five unrelated measures; the harmony of the related measures. Arrange the related measures in a row at equal intervals apart, the smallest first and the largest last, and observe how you have in your arrangement not only a harmony of measures which the scale-relationship gives, but you have, also, in the connection of the measures, a rhythmic relationship. The eye is led from measure to measure, just as it was led in the scale of values from value to value. By rearranging the rhythm of the measures, the movement can be made to change its direction and also its shape. By bringing the squares close together the movement becomes abrupt. Separating the squares by a larger interval, you can make the movement more gradual.

There is another point of view from which the measure must be considered. Every measure is a force of attraction, and the amount of this attraction is determined (other things being equal) by the measure itself. A large measure attracts more attention than a small one. The measure of two attracts twice as much attention as the measure of one. We have in our scale of measures, therefore, a scale of visual attractions proportioned as 1 to 2, to 4, to 8, to 16, to 32. Break up the scale and scatter the squares over your paper and observe that the eye is no longer led in a rhythm, but is held at rest by the opposition of attractions at the point which is their centre of equilibrium. When the problem is, to find this point, we must remember the law of balance: that equal attractions (measures in this case) balance at equal distances on a straight line connecting their centres, and that unequal attractions balance in the same way but at distances inversely proportional to them. In balancing tones we considered the element of contrast, measures being equal. In balancing measures we consider what they amount to respectively. The centre of equilibrium may be indicated by a point, or more satisfactorily by a symmetrical outline enclosing all the balanced measures and having with them a common centre. When the measures are accidental and unrelated, as they were before we brought them into scale-relationship, they are nevertheless attractions which hold the eye at their centre, and the centre can be found, approximately, by means of a small unit of measurement taken as a common divisor. The centre can be approximately ascertained by visual feeling, but we are talking about a scientific

basis for design, to be a verification or correction of visual feeling. The part which visual feeling plays in design is well enough understood.

The third element of the spot of paint, the one which we have not yet considered, is shape. To study shape alone we avoid all differences of tone and measure. For tone we may take black on white paper, and for measure the square of an inch. Then we must vary the shape in every possible way without varying either the tone or the measure. It is a little difficult to vary the shape without varying the measure, but we can do it, approximately, with the help of an underlay of small squares put under a tracing paper upon which we draw. The power of estimating the measure of the shape, no matter how irregular it is, is a power which every draughtsman, every painter, every designer must have. Make as many different shapes as you can, all black on white paper, and all in the measure of the square of an inch. Observe that some of the shapes are rhythmical, suggesting a joint action or movement of parts, that others are symmetrical, suggesting opposition or contradiction of parts, while others show both rhythmic and symmetric elements. Shapes are in harmony when they have the same or a similar character. Straight lines go together in harmony. Curved lines have in common their curvature, and fall into classes, circles, spirals, etc. Square spots harmonize as squares, and round spots as rounds. Angles go together in scale-relations based upon degrees.

Observe, however, in this connection as in others, that a little difference is more disturbing than a large difference, when there is no sufficient reason for any difference at all, when the repetition of the same shape-character would be as satisfactory. Most perfect harmony exists, of course, between shapes which have one and the same character, so in design we prefer a repetition of similar elements to any composition of insignificant differences. We are, however, apt to have differences of character given to us in the terms or conditions of our problem. What we have to do is to make the best of these conditions. In such cases we can make up for any lack of harmony in shapes by harmony in other than shape-relations. Shapes are in harmony when they have the same measure (harmony of measure). They are in harmony when they have the same tone (harmony of tone). They may have the same value without having the same color, and the same color without having the same value. They may have the same color without having the same intensity, so that there are many ways of achieving harmony when there is no harmony of the shapes themselves.

Shapes having the same measure are in balance when they are reversed

and set side by side so as to contradict one another. A perfect balance or antithesis of shapes is what we call symmetry. Symmetry is, accordingly, a specific form of balance. It is shape-balance, and as such it must be distinguished from tone-balance and measure-balance. The only perfect balance of shapes is the balance of similar shapes set in reverse, one against the other, and having the same measure; but we may have a partial balance in the reversion and opposition of similar shapes when they have different measures.

When two or more shapes are arranged so as to suggest a joint action or movement, we have what may be called a rhythm of shapes. This rhythm may be straight or curved in its character, or it may combine both curvature and straightness. As the eye moves more rapidly upon a straight line than upon any other, a rhythm showing many straight lines, all having the same direction, will give to the eye the sense of rapid movement, and this sense of rapid movement is lost in a rhythm which shows many curves or angles upon which the eye moves more intricately and therefore more slowly. There is another element to be considered in connection with the rhythmic composition of shapes; that is the suggestion of a possible resistance. The idea of resistance does not lie in the shape of the spot of paint, in the shape itself, but in a mental association. If we wish to produce the sense of rapid motion we must be sure not to suggest any opposition or resistance. Rhythms set in contrary motion tend to balance one another, and in the measure in which they balance one another they bring the eye to the rest of equilibrium.

I have now described the spot of paint in its three elements, tone, measure, and shape, and I have shown, or tried to show, how each of these elements may follow the principles of balance, of rhythm, and of harmony, which, as we have seen, are principles of order and of beauty. In the practice of Pure Design, which is the composition of spots of paint for the sake of order and beauty, we begin with a few tones, measures, and shapes, and try to bring them into the relations of balance, rhythm, and harmony; in other words, into an idea of beauty. When we have achieved this, in the composition of a few elements, we do the same thing with a larger number, proceeding, thus, from comparatively simple to more and more difficult problems. The elements which we use in any problem are not necessarily simple. We may take simple tones, measures, and shapes, or we may take compositions of them. Then the problem takes the form of a composition of compositions. In order to rise to anything important in design, the designer must be able to think freely and easily

in the terms of his art. The designer must be able to think in tones, measures, and shapes precisely as the composer of music thinks in the sounds of voices and of instruments. The measure of his ability as a designer is then revealed in his power to think of many things in single ideas, and to express in single ideas many things. At first a somewhat painful effort has to be made to bring the composition of tones and measures and shapes into the lawful relationship of a single idea; but, by degrees, the designer comes to think of his tones, measures, and shapes in lawful forms only. He is then a master, and he will follow the suggestions of his imagination as it leads him into the world of tone-, measure-, and shape-ideas. This world must be as wonderful as the world of musical sounds. We know something of that in the revelations which the great composers of music have given us in their compositions. Of the possibilities of Pure Design, we can only guess what they may be. Then, when it comes to Design in Representation, and we have in addition the lawful composition of tones, measures, and shapes, the expression of visual knowledge in the form of true ideas, we rise to still higher possibilities in the connection and relationship of Beauty with Truth. As we rise above the accidents of vision or of memory to the knowledge of things seen in their ideas or ideals, we discover that our knowledge of nature or life is a knowledge of Nature's consistency, of her balances, her rhythms, her harmonies, her order, her incomparable beauty. In other words, as science rises from particulars to what is general and universal, as she rises to the understanding of principles and laws, causes and sequences, she comes to a conception of nature as pure design. The statement of scientific truth becomes an illustration of pure design, and art and science become one. "At last the vision is revealed to him of a single science, which is the science of beauty everywhere." (Plato, Symposium, § 210.)